§10. Application of High Power ICP to Fusion Oriented Experiments of Erosion and Dust Formation Using Graphite and Refractory Metal Materials

Uesugi, Y., Husie, T., Tanaka, Y. (Kanazawa Univ.),
Ohno, N. (Nagoya Univ.),
Masuzaki, S., Tomita, Y., Goto, M.

Dust particles collected in magnetically confined fusion devices have many significant effects on a fusion reactor, such as tritium retention, impurity release, degradation of vacuum sealing and electrical isolation, etc. Since the dust particles collected on the first walls of fusion devices are formed by series of different plasma shots, it is not easy to clarify the fundamental processes of the dust formation mechanism in the fusion plasmas. So far, laboratory scale experiments using a high density divertor simulator with DC discharges[1], DC glow plasmas and so on, mainly contribute to experimental studies on the basic mechanism of dust formation.

In the present experimental study high power inductively coupled plasmas(ICPs) with a power level of 10~20 kW are used to study plasma-material surface interactions and dust formation mechanism. High pressure ICPs have characteristic features, such as high density(10^{19}~10^{21} m^{-3}), high heat flux(~1 MW/m^2), flexible working gas mixtures and so on. These plasma features are very helpful to study the material erosion, redeposition and dust formation, comparing with other laboratory experiments with different plasma parameter ranges.

Here initial results from the experiments of argon or argon-hydrogen mixture plasma irradiation onto graphite targets are reported. The electron temperature and density of the plasmas near the target are ~1 eV and ~$10^{20}m^{-3}$, respectively. Since the surface temperature of the graphite targets are 1300~1600 K and the incident energy of ion and neutral particles is below several eV, dominant processes of graphite target erosion should be radiation enhanced sublimation(RES) and chemical sputtering in our experiment. Figure 1 shows a picture of Ar plasma irradiation experiment. The target is placed at downstream region ~250 mm away from the core plasmas and is inclined to measure the surface temperature by radiation thermometer. In Figs 2(a)~(d) surface modification of graphite target in different irradiation condition are shown. Just a 30 minutes plasma irradiation changes the surface morphology strongly as shown in Fig. 2. In the present preliminary experiments, graphite targets are mainly eroded not deposited by plasma irradiation of Ar and Ar+H_2, but small dusts of ~1 μm size are observed in Ar+H_2 plasma(Figs. 2(c), (d)). We have completed to develop a new ICP device[2] for plasma irradiation experiments. So far argon(60 slpm)-hydrogen(12 slpm) mixture plasma can be generated to irradiate the graphite target. Figure 3 shows the electron temperature and density of argon plasmas at the irradiation region. High density(~$10^{20}m^{-3}$) and low temperature(1~2 eV) plasma irradiation experiments is in progress and CH_4 plasma irradiation experiments are being prepared to study the effect of reactive hydrocarbon molecules on carbon erosion/deposition and dust formation processes.

References

[1]Ohno. N., Kobayashi, Y., et al.:J. Nucl. Mater., **337-339**(2005)35.
[2]Tanaka, Y. et al.:Appl. Phys. Letts. **90**(2007)71502.

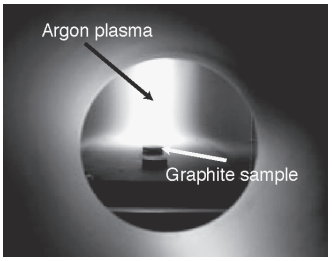

Fig. 1 Picture of graphite targets during argon plasma irradiation in the newly developed ICP. Three samples are fixed in line.

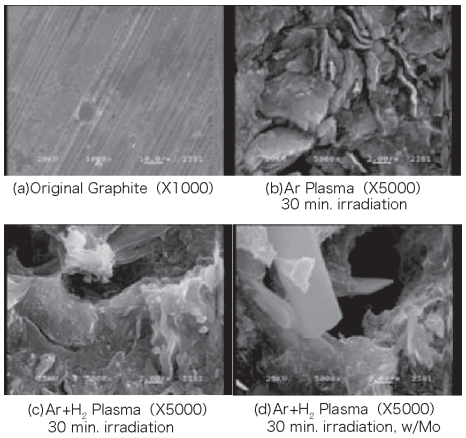

Fig. 2 SEM pictures of graphite target in different irradiation condition using old ICP at P_{rf}=13 kW.

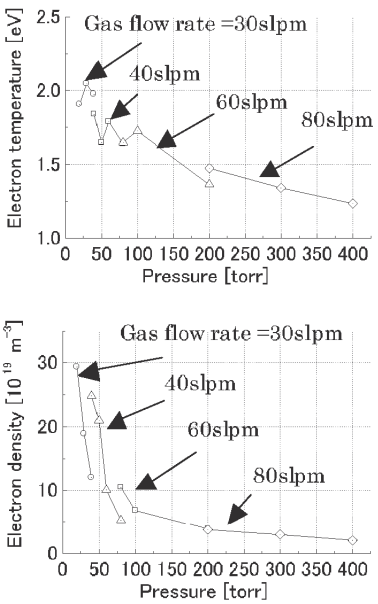

Fig. 3 Ar gas pressure dependence of the electron temperature(top) and density(bottom) measured by single probe. The fed rf power is kept at 13 kW.